# APPARATUS AND MANUFACTURING METHOD FOR BORDER LIGHTING

## BACKGROUND OF THE INVENTION

The invention relates to the lighting arts. It is especially applicable to the illumination of border areas such as the sides of staircases and rooms, and will be described with particular reference thereto. However, the invention will also find application in other areas where a linear lighting apparatus is beneficial, such as in outdoor building border lighting and lighted signs.

Border lighting includes strips of lights or light-emitting material laid along borders of rooms, steps, staircases, and the like. Border lighting enhances safety and increases the brightness of an enclosed space. It can also have aesthetic value. Border lighting is also commonly used outdoors for applications such as safety lighting, lighted signage, and building outlining.

Border lighting strips typically have certain characteristics that differ from general lighting applications. Border lighting is usually not used as primary illumination, and so the luminous intensity requirements are somewhat relaxed. However, border lighting strips are often placed in areas where physical damage to the strip is likely. For example, a border lighting strip along a step of a staircase is likely to be occasionally stepped upon. Outdoor border lighting strips are exposed to the elements. Thus, physical sturdiness is an important quality, and a watertight sealing can also be advantageous.

Another characteristic is that border lighting strips are often used in substantial lengths. For example, installing border lighting along the boundaries of a typical room with dimensions of 18 feet by 15 feet will require approximately 66 feet of strip lighting, neglecting additions or subtractions due to doors, wall protrusions or recesses, and the like. Thus, manufacturing costs

become a significant commercial factor, and a low manufacturing cost per unit length is desirable.

Presently, most border lighting is provided by neon border tube systems. However, neon tubes are very fragile, have high power consumption, and are difficult to install. Neon tubes typically require high voltages, thus requiring a specialized power supply , and the high voltages can raise safety concerns. The materials used in neon tubes can present environmental issues.

Border lighting systems that use linear arrays of discrete light emitting devices (LEDs), such as light emitting diodes, are also known. In one prior art border lighting system, the LEDs are physically and electrically mounted to a printed circuit board (PCB) which is surrounded by a light-transmissive housing. The prior art LED-based border lighting systems have several disadvantages, including complex assembly, fragility, and reliability issues arising from the complexity and fragility. Past LED-based border lighting also requires a relatively large number of LEDs per unit length which increases manufacturing and operating costs.

Prior art border lighting using either neon tubes or LED elements affixed to a PCB support is physically rigid and inflexible. These lighting strips cannot be “bent” around corners in a flexible manner.

The present invention contemplates an improved border lighting strip that overcomes the above-mentioned limitations and others.

## BRIEF SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, a border lighting strip is disclosed. An electrical cable includes a plurality of electrical conductors. A plurality of light emitting devices (LEDs) are arranged

alongside the electrical cable and electrically connected thereto. A sheath at least partially made from a light transmissive material has a hollow region adapted to receive the LEDs. The sheath has an integrally formed cylindrical lens arranged to optically cooperate with the LEDs.

In accordance with another embodiment of the present invention, a linear lamp is disclosed. An essentially hollow tube of translucent or transparent material has a plurality of light emitting elements arranged within. At least one electrical wire is arranged within the tube for supplying electrical power to the light emitting elements.

In accordance with yet another embodiment of the present invention, a lighting strip is disclosed. A cord includes a plurality of parallel conductive wires and an insulating coating. A plurality of light emitting elements are affixed to the cord and arranged to receive electrical power therefrom. An at least partially light transmissive tube surrounds the plurality of light emitting elements and at least a portion of the cord.

In accordance with still yet another embodiment of the present invention, a method is disclosed for manufacturing a lighting strip. A plurality of light emitting devices are electrically connected to an electrical cable to form a linear light source. A transparent or translucent sheath is extruded. The sheath is adapted to receive the linear light source. The linear light source is inserted into the extruded sheath.

One advantage of the present invention is that it provides a rugged and durable border lighting, which can also be made water-tight.

Another advantage of the present invention is that it is manufactured in a simple and cost-effective manner.

Another advantage of the present invention is that it provides physically flexible border lighting.

Yet another advantage of the present invention is that the light is spread using an optical component built into the protective tube housing to minimize the number of light emitting elements required per unit length.

Numerous additional advantages and benefits of the present invention will become apparent to those of ordinary skill in the art upon reading and understanding the following detailed description.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention may take form in various components and arrangements of components, and in various steps and arrangements of steps. The drawings are only for purposes of illustrating the preferred embodiments and are not to be construed as limiting the invention.

FIGURE **1** shows a perspective view of a length of border lighting that suitably practices an embodiment of the invention.

FIGURE **2** shows a cross-sectional view of the embodiment of FIGURE **1**.

FIGURE **3** shows a cross-sectional view of the light transmissive extruded sheath of the embodiment of FIGURE **1**.

FIGURE **4** shows a cross-sectional view of one of the plurality of light emitting elements of the embodiment of FIGURE **1** along with its mount.

FIGURE **5** shows a cross-sectional view of another border lighting that suitably practices an embodiment of the invention.

FIGURE **6** schematically shows an exemplary strip light manufacturing process that suitably practices an embodiment of the invention.

## DETAILED DESCRIPTION OF THE INVENTION

With reference to FIGURES **1**, **2**, **3**, and **4**, a length of an exemplary border lighting tube or lamp **10** is described. The light source **10** includes a plurality of light emitting elements **12** arranged alongside an electrical cable or cord **14**. The cable **14** includes a plurality of electrically insulated wires, represented in FIGURE **2** by two thickened regions **14A**, **14B** corresponding to two wires. The exemplary light emitting elements **12** are light emitting diodes such as phosphide-based red light emitting diodes, blue or blue/green nitride-based light emitting diodes, phosphor-coated UV light emitting diodes emitting white or other colored light, or the like. Mixtures of light emitting diodes of various types on the cable **14** are also contemplated, as are other light emitting elements such as miniature incandescent lamps.

Each of the light emitting elements **12** preferably includes a lead frame having leads **12A**, **12B** for electrical connection to the light emitting element **12**. The formation of the light emitting element **12**, e.g. light emitting diode, and its connection to leads **12A**, **12B** of a lead frame can be performed in a large number of ways which are well known to those skilled in the art. The light emitting elements **12** are electrically powered by the cable **14** through leads **12A**, **12B** (FIGURE **2**). The leads **12A**, **12B** are connected to the cable wires **14A**, **14B**, for example by crimping or soldering. Crimped connections are simple to implement and are advantageously rugged compared with many types of soldering bonds.

The tube lighting **10** also includes an at least partially light transmissive housing, tube, or sheath **16** which is essentially hollow and surroundingly receives the light emitting elements **12** and at least a portion of the electrical cable **14**. The sheath **16** shields the light emitting elements **12**

and the covered portion of the cable **14** from external influences, and is optionally watertight. However, the sheath **16** is at least partially light transmissive at least for light generated by the light emitting elements **12**.

The light emitting elements **12** are advantageously supported inside the sheath **16** by a support, socket, or mount **22**. In the exemplary embodiment of FIGURES **1** through **4** there is a separate mount **22** corresponding to each light emitting element **12**. However, a mount that supports a plurality of light emitting elements is also contemplated. The exemplary mount **22** has an opening **24** through which the cable **14** passes. However, the mount **22** could also be connected to the cable **14** in other ways, such as by clamping or by the use of an adhesive.

As best seen in FIGURES **2** and **3**, the housing, sheath, or tube **16** includes an integral optical element **18**, which in the illustrated embodiment is a cylindrical lens **18**, that optically cooperates with the light emitting elements **12** to distribute the emitted light using one or more selected operative modes. In one operative mode, the integral optical element **18** provides wave guiding that distributes the light along the tube. In another operative mode, the optical element **18** includes one or more refracting portions that refract light generated by the light emitting elements in a manner which enhances distribution of light perpendicular to the tube **16**. It is also contemplated that the single cylindrical lens **18** provide both wave guiding and perpendicular refracting.

Those skilled in the art will recognize that forming the sheath **16** using a material having a high refractive index enhances the effectiveness of both the refracting and the wave guiding operative modes. Furthermore, the optical behavior is optionally not limited to a particular optical element **18** of the sheath **16**. Rather, the entire sheath **16** or significant portions thereof beyond the optical element **18** optionally cooperate with the light emitting elements **12** to

achieve a desired light distribution. Through the refractive and/or wave guiding activity of the optical element **18** with optional involvement of the sheath **16**, the border tube **10** can be thickened more than would be otherwise cosmetically acceptable, and the number of light emitting elements **12** per unit length can be reduced.

In the embodiment illustrated in FIGURES **1** through **4**, the light emitting elements **12** are arranged in a straight line facing a single direction. However, embodiments where the light emitting elements are arranged in a curved, spiral or other pattern are also contemplated. Furthermore, the sheath or tube **16** can be made from either a rigid or a flexible transparent or translucent material. A flexible sheath **16** results in a flexible linear border lighting **10** which can be arranged to follow corners and other turns within turning radius limits imposed by the sheath **16** or the cable **14**. However, a rigid sheath **16** may be preferred for horizontal wall mounting and other applications.

With reference to FIGURE **5**, a strip light **100** that suitably practices another embodiment of the invention is shown in cross-section. The light source **100** includes a plurality of light emitting elements **112** arranged alongside an electrical cable **114**. The cable **114** includes a plurality of electrically insulated wires, represented in FIGURE **5** by two thickened regions **114A**, **114B** corresponding to two wires. The exemplary light emitting elements **112** are light emitting diodes such as phosphide-based red light emitting diodes, blue or blue/green nitride-based light emitting diodes, phosphor-coated UV light emitting diodes emitting white or other colored light, or the like. Mixtures of light emitting diodes of various types on the cable **114** are also contemplated, as are other light emitting elements such as miniature incandescent lamps.

Each of the light emitting elements **112** preferably includes a lead frame having leads **112A**, **112B** for electrical connection to the light emitting

element **112**. The formation of the light emitting element **112**, e.g. light emitting diode, and its connection to leads **112A**, **112B** of a lead frame can be performed in a large number of ways which are well known to those skilled in the art. The light emitting elements **112** are electrically powered by the cable **114** directly through contacts **112A**, **112B**, for example by crimping or soldering. Crimped connections are advantageously rugged compared with many types of soldering bonds. The tube lighting **100** also includes a translucent or transparent sheath **116** which is essentially hollow and surroundingly receives the light emitting elements **112** and at least a portion of the electrical cable **114**. The sheath **116** shields the light emitting elements **112** and the covered portion of the cable **114** from external influences, and is optionally watertight. However, the sheath **116** is substantially light transmissive at least for light generated by the light emitting elements **112**.

In the embodiment of FIGURE **5**, the transparent or translucent housing, sheath, or tube **116** includes an integral optical element **118**, which in the illustrated embodiment is a cylindrical lens **118**, that optically cooperates with the light emitting elements **112** to distribute the emitted light using one or more selected operative modes. In one operative mode, the integral optical element **118** provides wave guiding that distributes the light along the tube. In another operative mode, the optical element **118** includes one or more refracting portions that refract light generated by the light emitting elements in a manner which enhances distribution of light perpendicular to the tube **116**. It is also contemplated that the single cylindrical lens **118** provide both wave guiding and perpendicular refracting.

Those skilled in the art will recognize that forming the sheath **116** using a material having a high refractive index enhances the effectiveness of both the refracting and the wave guiding operative modes. Furthermore, the

optical behavior is optionally not limited to a particular optical element **18** of the sheath **116**. Rather, the entire sheath **116** or significant portions thereof beyond the optical element **118** optionally cooperate with the light emitting elements **112** to achieve a desired light distribution. Through the refractive and/or wave guiding activity of the optical element **118** with optional involvement of the sheath **116**, the border tube **100** can be thickened more than would be otherwise cosmetically acceptable, and the number of light emitting elements **112** per unit length can be reduced.

In the embodiment illustrated in FIGURE **5**, the light emitting elements **112** are arranged in a straight line facing a single direction. However, embodiments where the light emitting elements are arranged in a curved, spiral or other pattern are also contemplated (not shown). Furthermore, the sheath or tube **116** can be made from either a rigid or a flexible transparent or translucent material. A flexible sheath **116** results in a flexible linear border lighting **100** which can be arranged to follow corners and other turns within turning radius limits imposed by the sheath **116** or the cable **114**. However, a rigid sheath **116** may be preferred for horizontal wall mounting and other applications.

With reference to FIGURE **6**, an exemplary manufacturing process **200** for manufacturing a border lighting strip such as the exemplary border lighting strip **10**, **100** is described. In the case where the light emitting devices (LEDs) include a mount, e.g. the mount **22** of FIGURES **1**, **2**, and **4**, an LED is attached **202** to a mount. The attaching **202** is repeated **204** for all the LEDs. The attaching **202** is advantageously both physical and electrical, with the latter accomplished by soldering, wire bonding, or the like.

A mount is attached **208** to the cable by crimping, soldering, or the like, and the attaching **208** is repeated **210** for all the mounts. It will be appreciated that the order of the attachings **202**, **208** is unimportant, i.e. the

LEDs can be attached **202** to the mounts followed by attaching **208** of the mounts to the cable, or alternatively the mounts can be attached **208** to the cable and the LEDs attached **202** to the mounts. In most manufacturing situations, however, it will be preferred to attach **202** the LEDs to the mounts first. For manufacturing of the border lighting embodiment of FIGURE **5** wherein no mount is employed, the LEDs are directly attached to the cable using crimping, soldering, or the like, without the intercession of a mount. The electrical connecting **202**, **204**, **208**, **210** of the LEDs to the cable forms a linear light source **214**.

The sheath, e.g. the sheath **16** of FIGURES **1** through **3** or the sheath **116** of FIGURE **5**, can be formed by any suitable manufacturing process. A preferred method for the sheath formation is extrusion molding **216**. Extrusion has a number of manufacturing advantages, including: providing a high degree of freedom in selecting the cross-sectional shape; providing the ability to form a wide range of materials including both flexible and rigid formed materials; and the providing the ability to generate an essentially infinitely variable extruded tube length. The linear light source **214** is inserted **218** into the extruded **216** sheath to form the border lighting **220**.

The invention has been described with reference to the preferred embodiments. Obviously, modifications and alterations will occur to others upon reading and understanding the preceding detailed description. It is intended that the invention be construed as including all such modifications and alterations insofar as they come within the scope of the appended claims or the equivalents thereof.